Stochastic Super-Resolution for Downscaling Time-Evolving Atmospheric Fields With a Generative Adversarial Network

Year: 2020 | Citations: 165 | Authors: J. Leinonen, D. Nerini, A. Berne

Abstract

Generative adversarial networks (GANs) have been recently adopted for super-resolution, an application closely related to what is referred to as “downscaling” in the atmospheric sciences: improving the spatial resolution of low-resolution images. The ability of conditional GANs to generate an ensemble of solutions for a given input lends itself naturally to stochastic downscaling, but the stochastic nature of GANs is not usually considered in super-resolution applications. Here, we introduce a recurrent, stochastic super-resolution GAN that can generate ensembles of time-evolving high-resolution atmospheric fields for an input consisting of a low-resolution sequence of images of the same field. We test the GAN using two data sets: one consisting of radar-measured precipitation from Switzerland; the other of cloud optical thickness derived from the Geostationary Earth Observing Satellite 16 (GOES-16). We find that the GAN can generate realistic, temporally consistent super-resolution sequences for both data sets. The statistical properties of the generated ensemble are analyzed using rank statistics, a method adapted from ensemble weather forecasting; these analyses indicate that the GAN produces close to the correct amount of variability in its outputs. As the GAN generator is fully convolutional, it can be applied after training to input images larger than the images used to train it. It is also able to generate time series much longer than the training sequences, as demonstrated by applying the generator to a three-month data set of the precipitation radar data. The source code to our GAN is available at https://github.com/jleinonen/downscaling-rnn-gan.